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Solar receivers operation and lifetime

better thermomechanical knowledge

better optical temperature measurements

SFERA-III

Final Event

December 13, 2023 | Madrid, Spain

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THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT NO 823802

How to **have** **better solar receivers**,

which are cheaper, have longer lifetime, and are more efficient ?

in 

we have improved **material knowledge** determination

thanks to **better instrumentation**,

both in lab and in-situ at RI CSP facilities.

Solar receivers operation and lifetime

better optical temperature measurements,
better thermomechanical knowledge

Mechanical health

Monitoring receiver material degradation thanks to self emitted acoustic events

Optical properties

Improving laboratory and field emissivity determination, methods and instruments

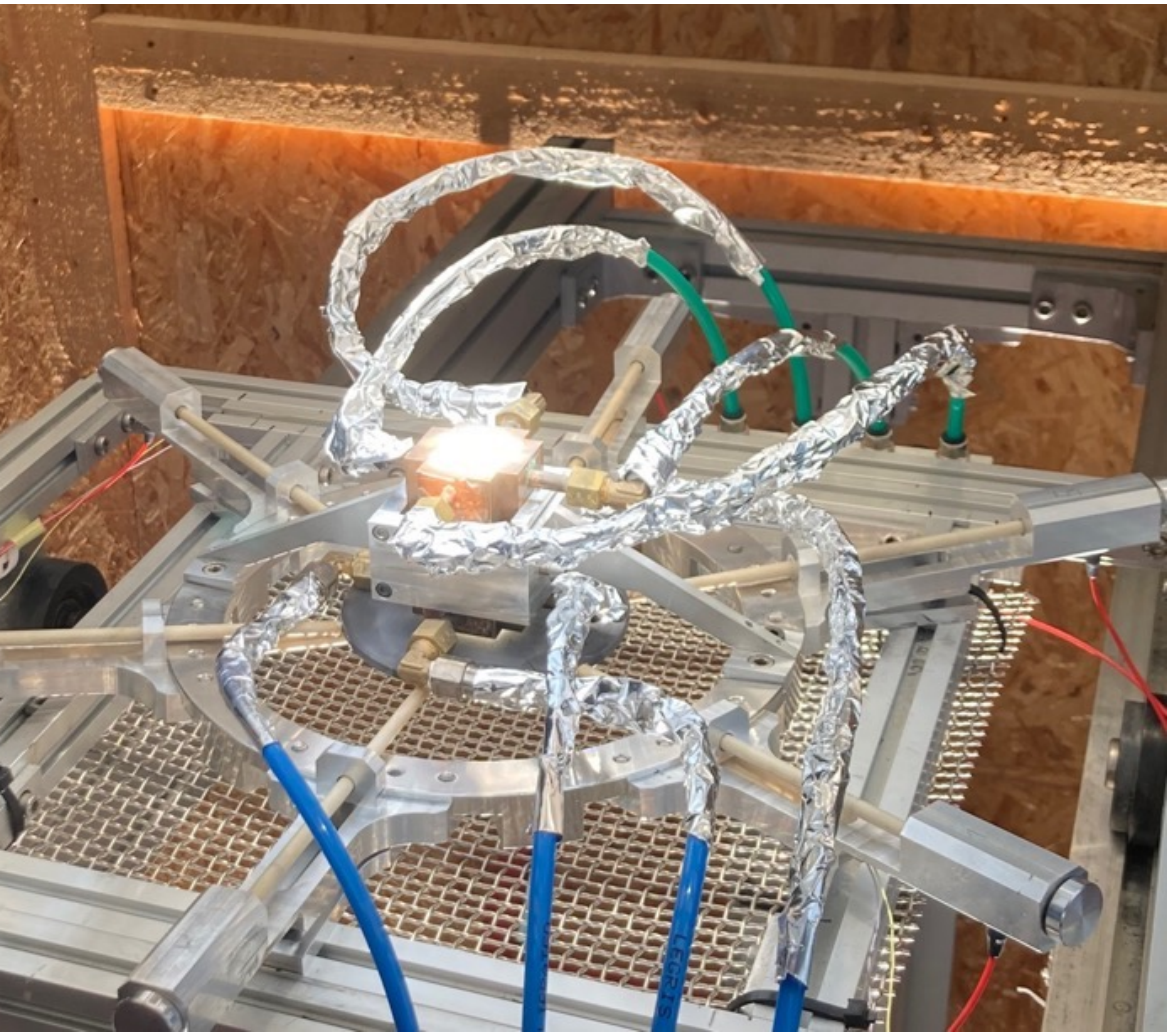
Thermography

Determining linear collectors temperature, hence vacuum losses, from UAV and IR cam

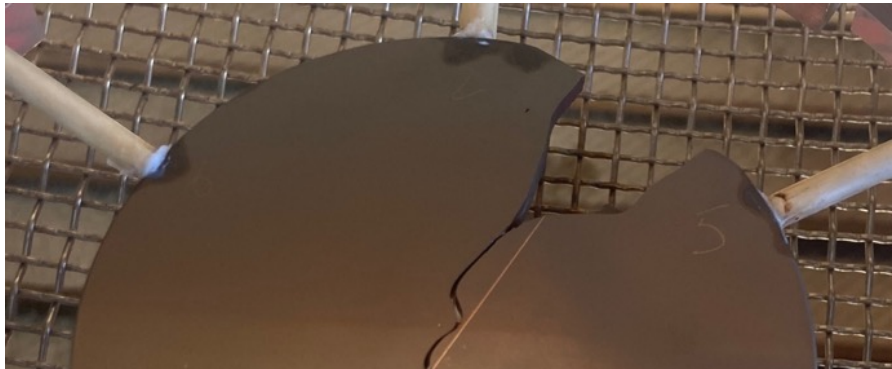
Accelerated aging

Improved test benches to observe receiver degradation, materials and properties

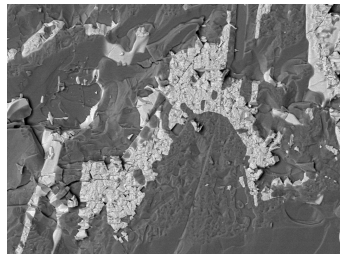
Mechanical health

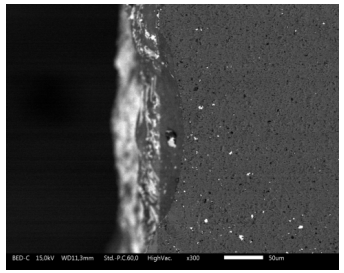


- *Listening to faults inside the components*
- Solar setup to assess material and components mechanical lifetime
- Improved monitoring self emitted acoustic events (AE) and temperature evolution
- Method improved to localize events
- Method improved to identify events
- In some cases: now capable of failure prediction (AI)

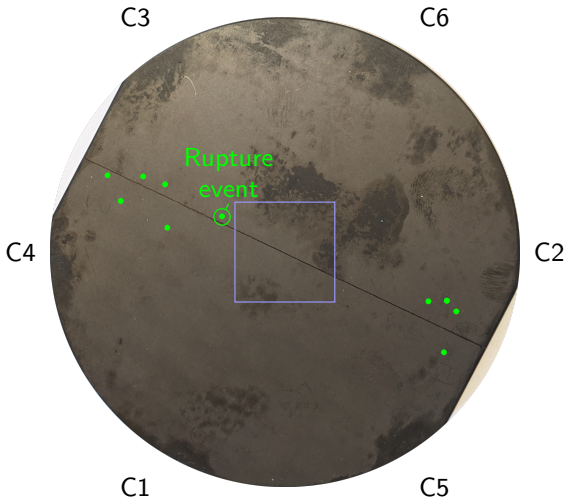


Mechanical health: AE+AI

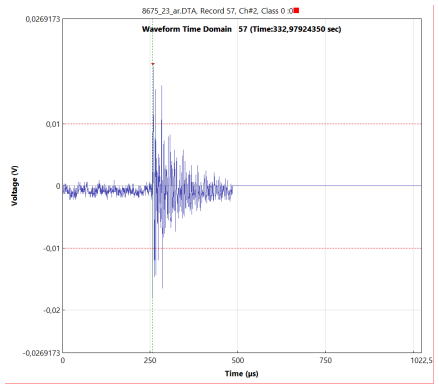


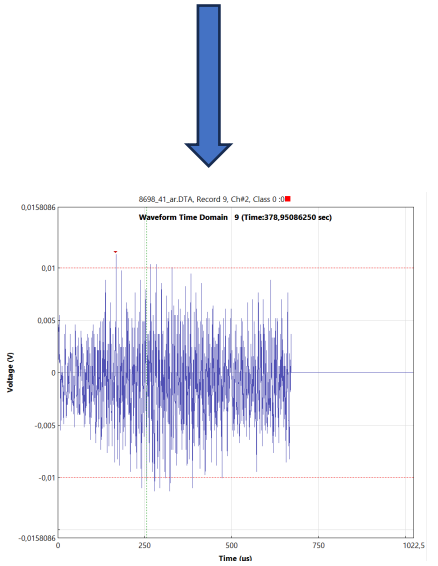


Microstructural damages analysis

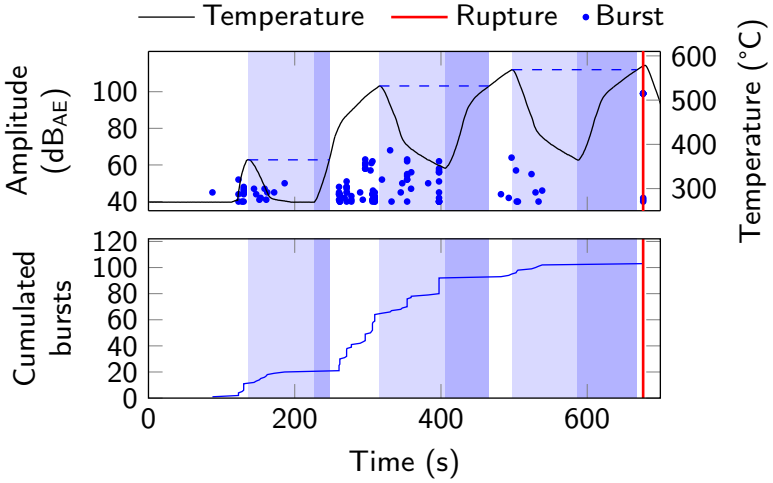


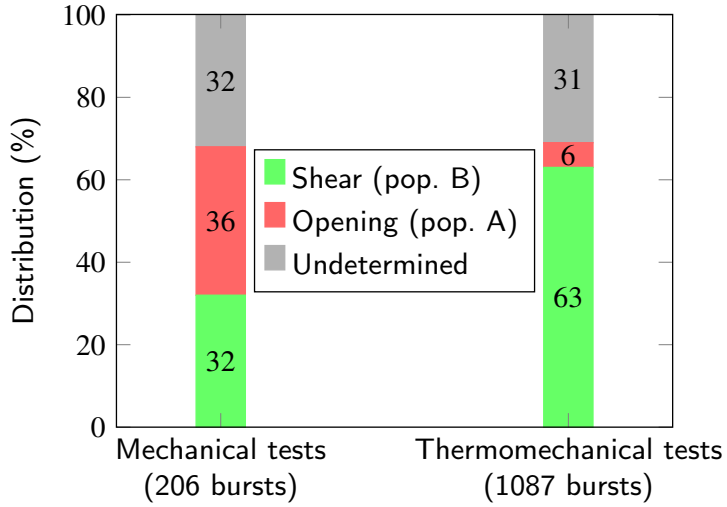
AI: events location





AI: differentiate mechanisms



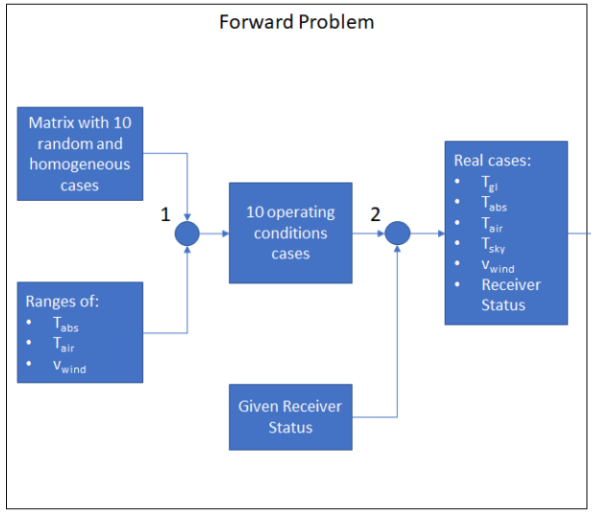


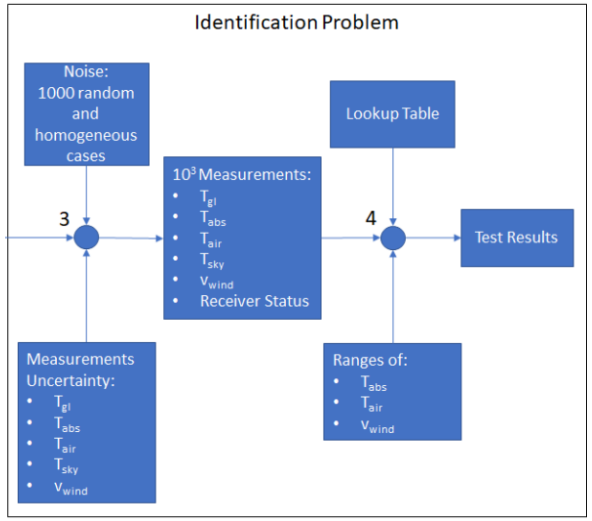
AI to ID events and failure: specific burst count & fault ID

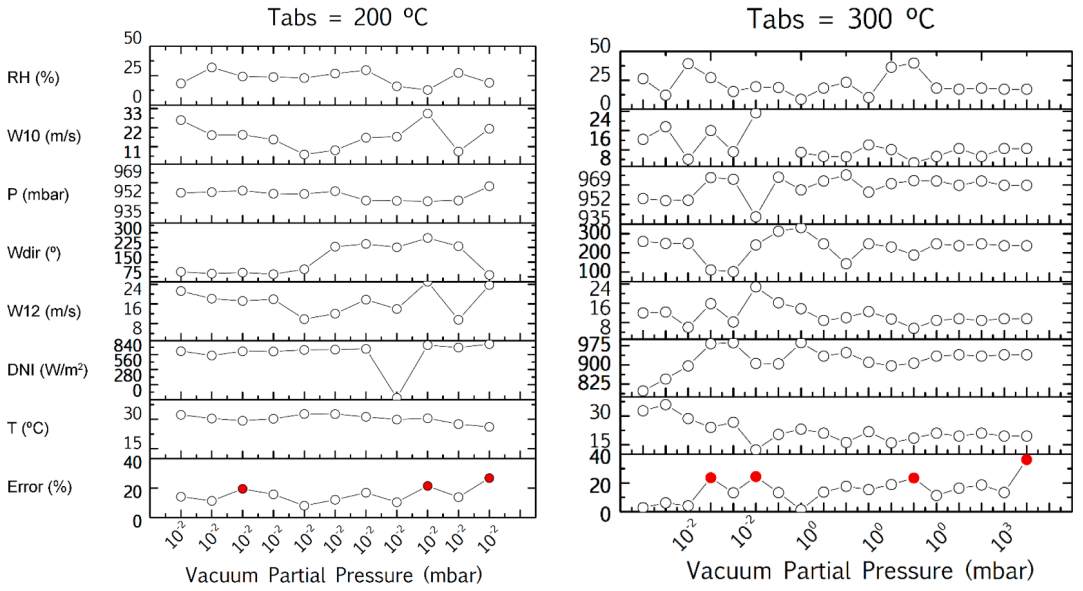
Thermography for linear receivers

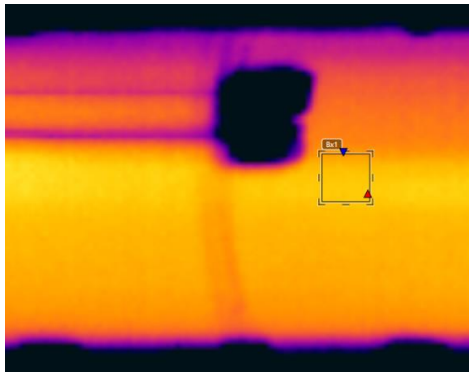
- Determine tube collectors performance: collector efficiency and vaccum-loss
- Improved tube collectors temperature measurements by infrared camera from UAV
- Laboratory and outdoor campaigns to determine and qualify improved models including parasitic meteorological bias correction and evaluation

Thermography for linear receivers

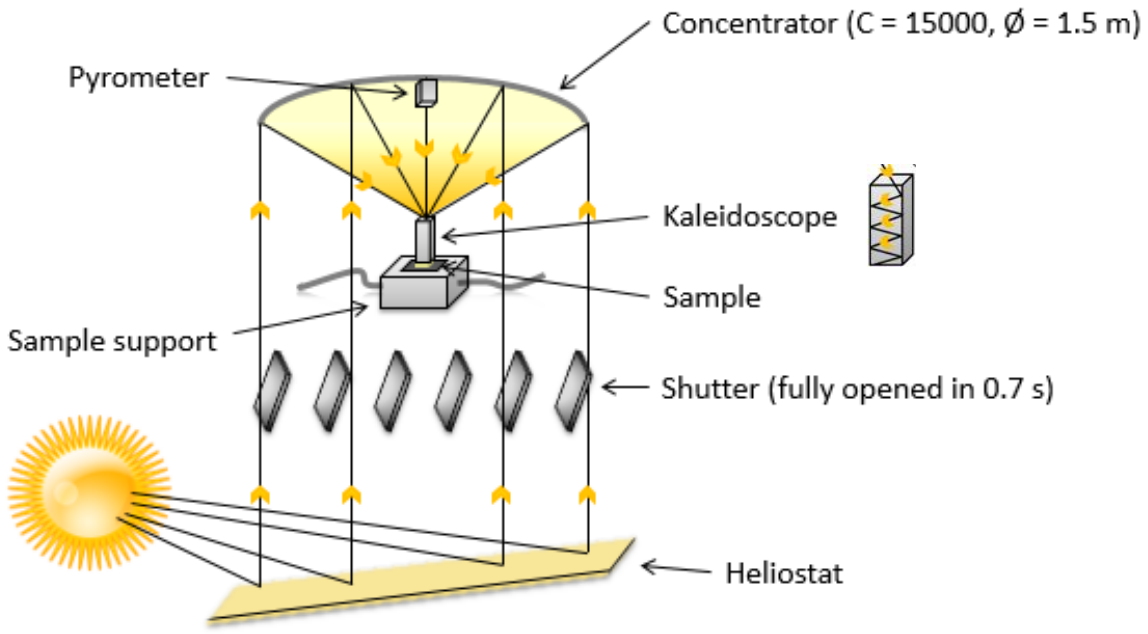




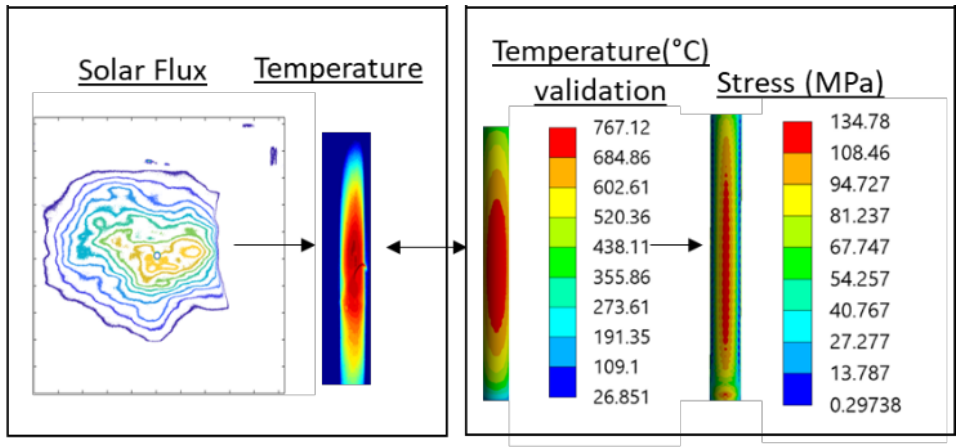




Accelerated ageing



- Two setups improved to determine solar receivers lifetime:
  - One setup for molten salt tubes
  - One setup for flat samples and assemblies
- Different thermal stresses possible
- Different analysis developed



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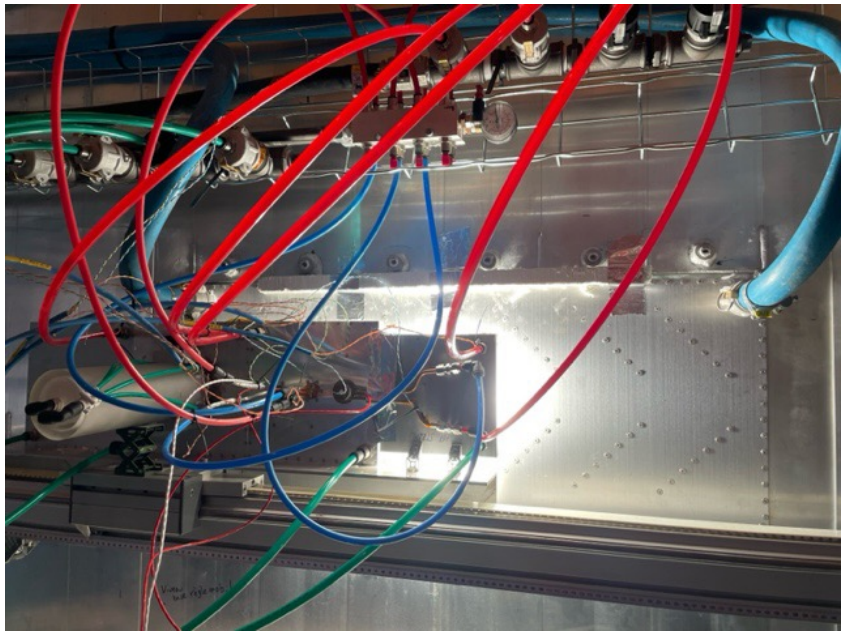
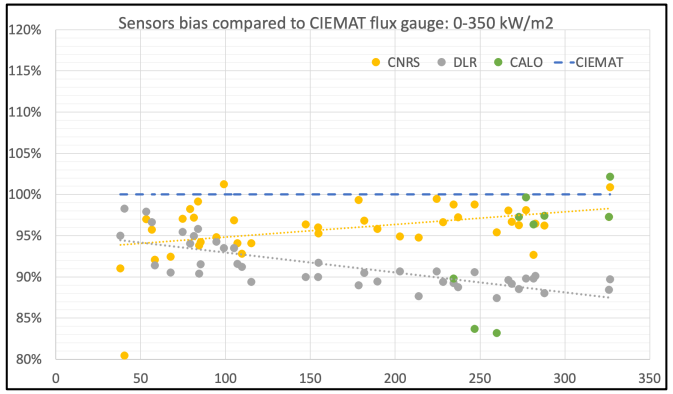
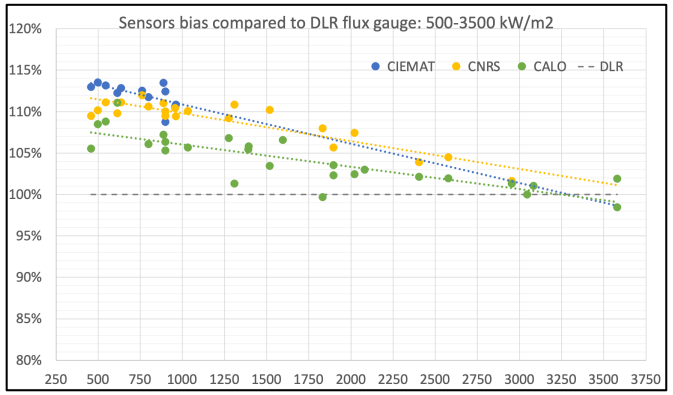
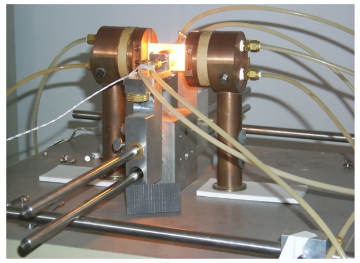


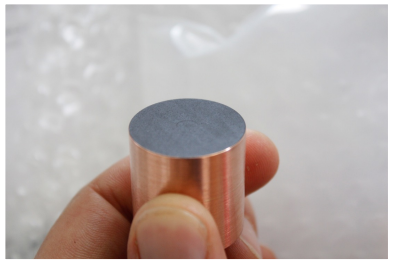
Flux sensors intercomparison to compare calibration and sensor technology behavior.

- Directionality and beam size sensitivity
- Spectral calibration correction









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better optical temperature measurements,
better thermomechanical knowledge

Mechanical health

Monitoring receiver material degradation thanks to self emitted acoustic events

Optical properties

Improving laboratory and field emissivity determination, methods and instruments

Thermography

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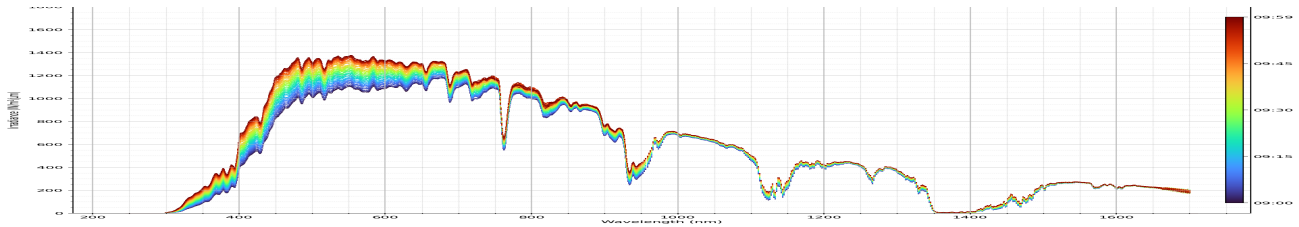
Optical properties: emissivity

Emissivity is the key optical parameter which characterize the collection of solar energy by the solar receivers, and also allows to measure remotely its temperature distribution with an infrared camera.

Better emissivity knowledge leads to:

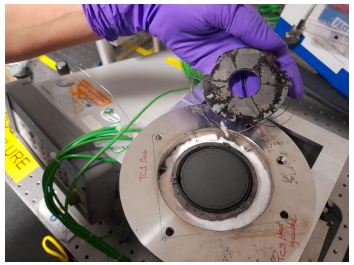
- Better receiver efficiency as it is operated closer to its maximum temperature,
- Better receiver lifetime as its optical status is monitored closely.



Toward in-field emissivity determination for central receiver systems

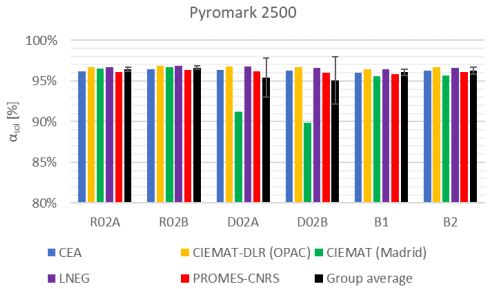
Services improvement

Two laboratory services were improved to extend their measuring range in temperature and better cover operational CSP parameters.



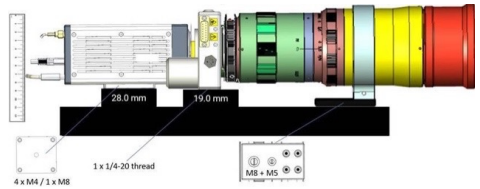
Services comparison

Eight laboratory services were compared in a round robin test with CSP receiver samples to evaluate their differences and improve their methodologies.



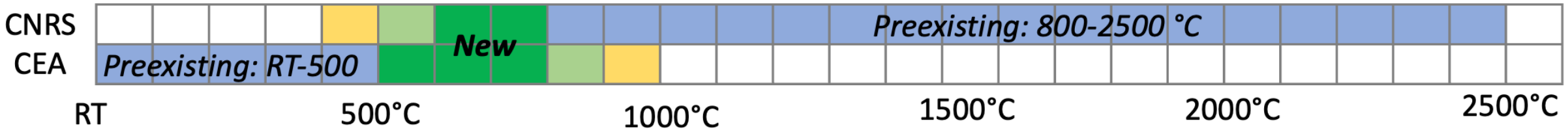
In-field prototype

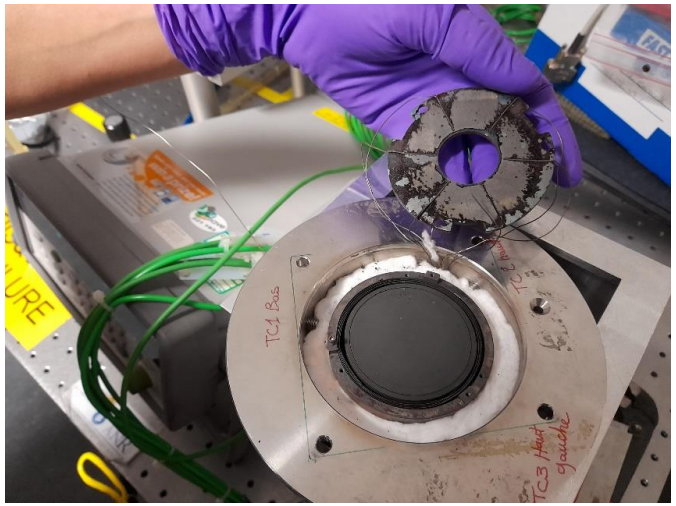
A new system has been developed to monitor in field emissivity of solar towers receivers and improve their temperature determination.



Emissivity services

The temperature ranges of reference services for emissivity determination has been extended for more CSP applications, including generation 3 CSR.





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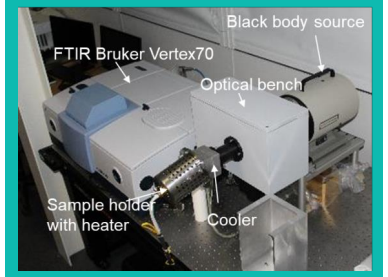

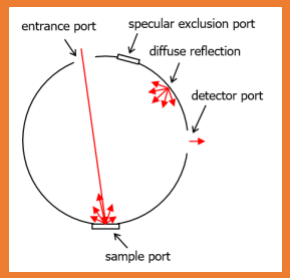

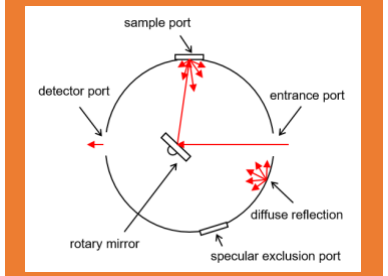

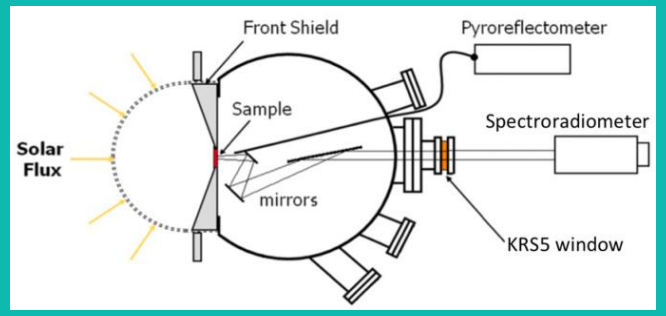

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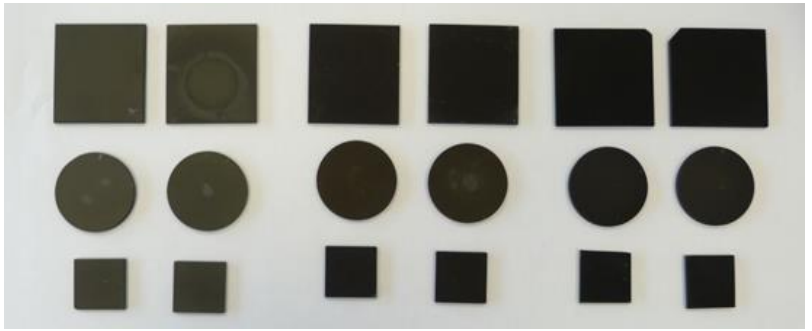
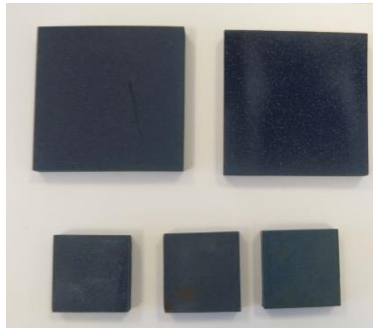
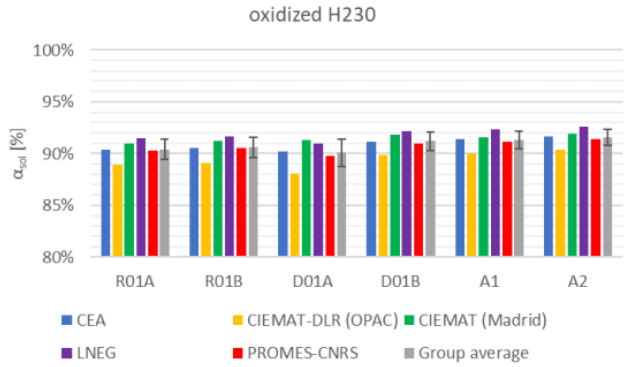
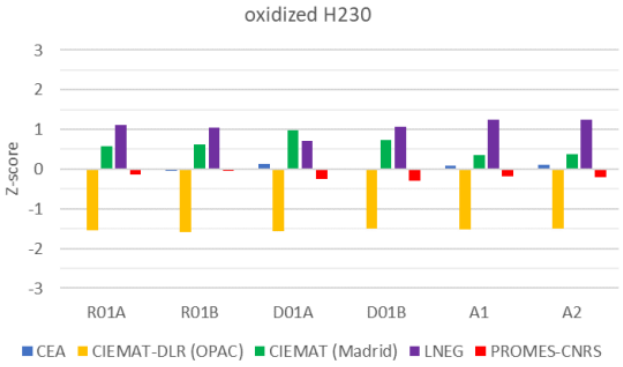
a) H230 samples



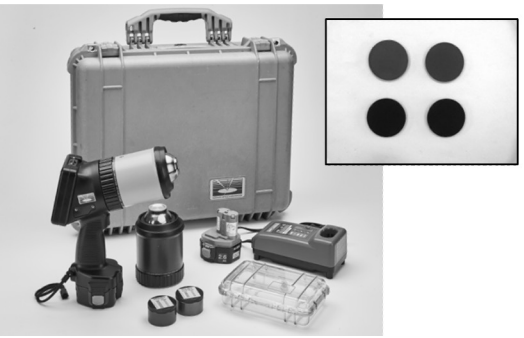
b) SiC samples

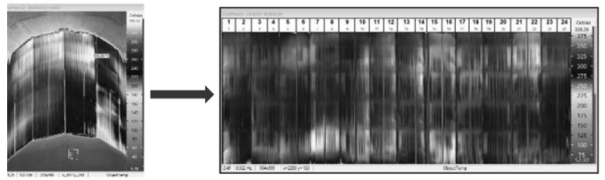


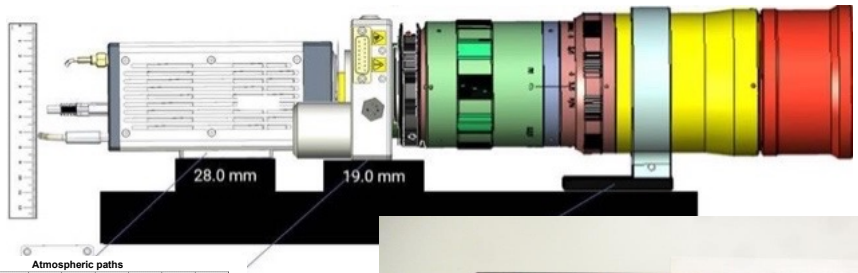


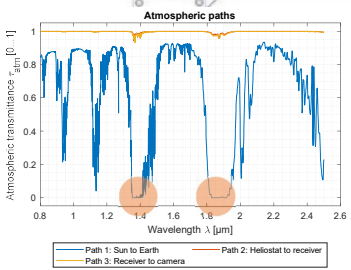


In-field prototype









Current state of the art:

- Emissivity measured locally, time to time, off operation
- Temperature is measured locally with sensor arrays, or remotely with single band IR cameras

➽ *difficult continuous monitoring*

➽ *limited measurement performance*

now

Multispectral camera with eSWIR detector and atmospheric corrections

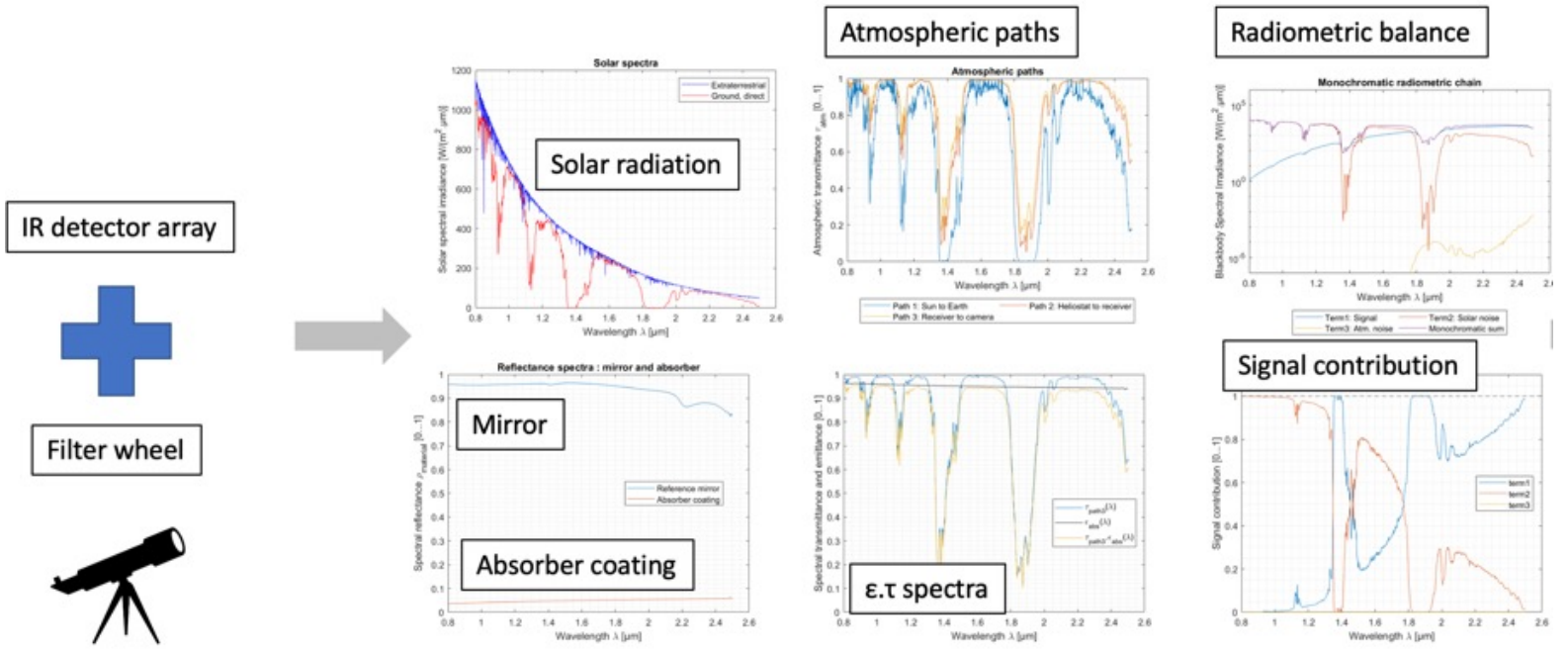
Spectral modeling software

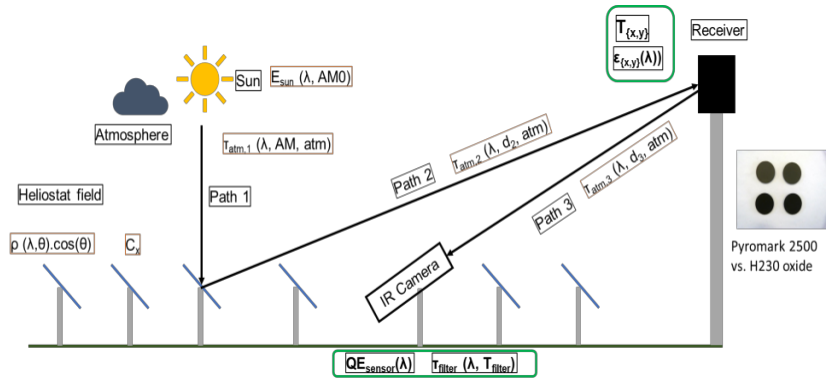
New software model for spectrum determination:

- Receiver behavior
- Atmospheric absorption
- Camera lens transmission
- Camera detector sensitivity

➽ *used to choose tradeoff for the prototype*

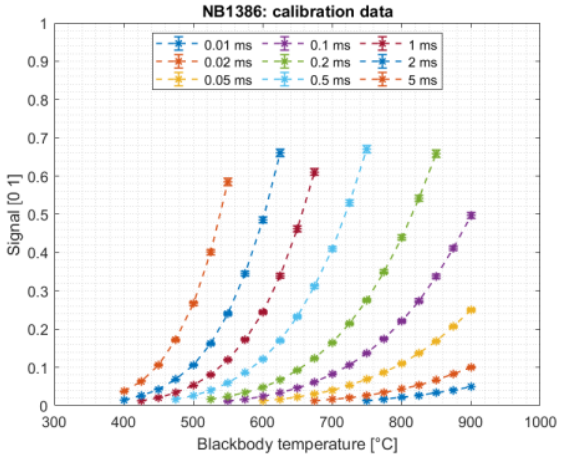
➽ *used for measurements correction*

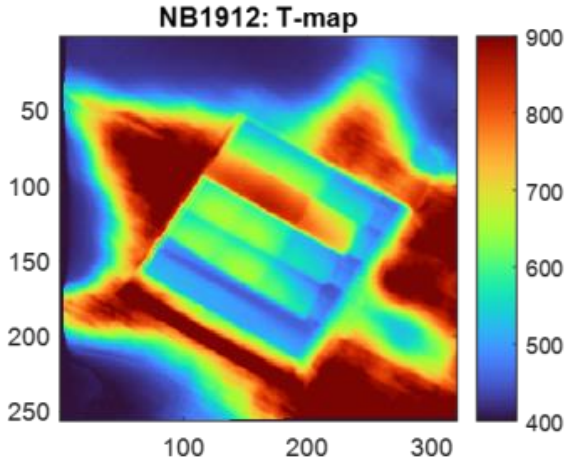


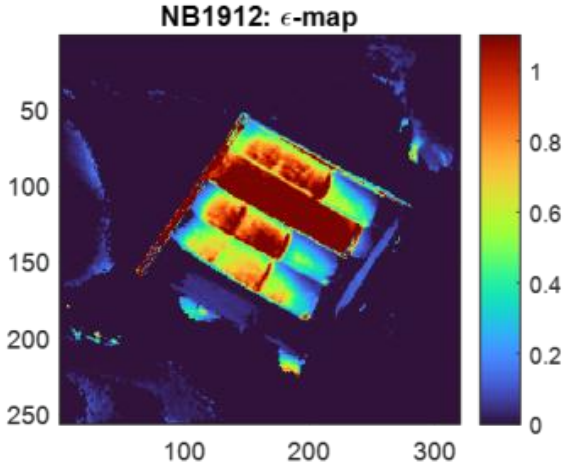


Development of spectral calculation tool SWIR to LWIR to choose best compromise

In-field prototype development







3 steps calibration and controls:

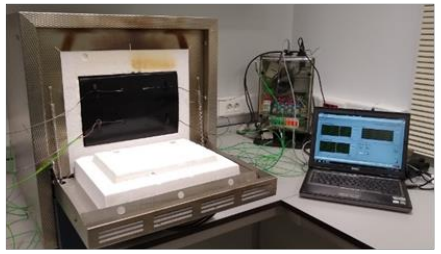
- With black body
- With samples in furnaces
- With samples at solar furnace

➽ *Verification outdoor at RI solar tower*

1 Blackbody

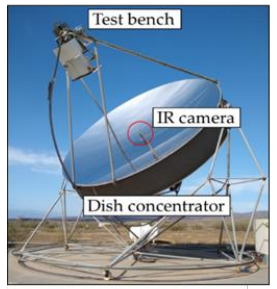
Calibration

2 Muffle furnace



Off-sun tests

3 Solar furnace



On-sun tests

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Future possible investigations

- Better emissivity measurements, in-situ and in-lab:
  - *Progress toward standardized procedures*
  - *Reduce in-lab differences and uncertainties*
- Better solar receivers temperature measurements:
  - *Improve calibration of IR cameras for CSP*
  - *Improve solarblind & atm SWIR corrections*
- Better accelerated ageing services:
  - *Improve temperature samples determination*
- Better process testing and efficiency measure:
  - *Improve concentrated flux measurements*
- Monitoring thermomechanical health of receivers:
  - *Data processing: clustering & id phenomenon*
  - *In-situ demo on large scale solar tower*

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Thank You

For Your Attention

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